OBSERVATIONS ON THE SOIL ACIDITY OF ERICACEAE AND ASSOCIATED PLANTS IN THE MIDDLE ATLANTIC STATES.

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In a recent paper[1] the writer described the results obtained on a trip in northern New England in June, 1919, where indicator solutions were carried into the field and tests made of the soil reactions of a number of species of Ericaceae and other families of plants thought to be sensitive in this respect.[2] Both before and since that trip similar observations have been made at a number of places in Pennsylvania and adjoining states, and in the present paper some of the results obtained are described[3]. The field work has been carried out largely at the writer's own expense, in the course of vacation outings, but funds for certain trips were obtained from the U. S. Bureau of Plant Industry, through Mr. Frederick V. Coville, Botanist of the Bureau.

The regions in which these observations have been made are presented in the following table, with summaries of their dominant geological and soil features. Those in the Appalachian Mountain and Piedmont Provinces are given first, from northeast to southwest, and then those on the Atlantic Coastal Plain, from north to south.

TABLE I.

Features of regions studied.

Locality	State	Surface Geology	Soil Character	Dominant soil reaction[4]	Ericaceae
Appalachian Mountain and Piedmont. (Alleghanian Zone.)					
Swamps north of Dover	N. J.	Siliceous glacial drift	Bog and upland peats	Mediacid	Abundant

[1]*Rhodora*, **21**:33-49, 1920.

[2]The use of indicators for this purpose has been described in *Journ. Wash. Acad. Sci.*, **10**:217-233, 1920. Sets of indicators for field work are now on the market.

[3]Southern New Jersey will be discussed in these PROCEEDINGS at a later date.

[4]The terms used for describing soil reactions have been defined in *Journ. Wash. Acad. Sci.*, **9**:305, 1919. Specific acidity is the amount of acid, and specific alkalinity the amount of alkali, present in a given solution, with reference to pure water as the unit. Specific acidity between 1 and 10 is called minimacid, between 10 and 100 subacid, between 100 and 1000 mediacid, and above 1000 superacid. Corresponding terms are used on the alkaline side. In addition, minimacid, neutral and minimalkaline reactions are grouped together as circumneutral.

Swamps south of Green Pond.....N. J.	Calcareous glacial drift	Bog and upland peats	Subacid	Common
Mountain ridges in central counties...Pa.	Siliceous rocks	Upland peat some bog peat	Mediacid	Abundant
Valleys in east-central counties.......Pa.	Calcareous rocks	Upland peat	Minimacid	Rare
Uplands in S. E. counties.............Pa.	Various igneous rocks	Upland peat	Subacid	Common
Uplands N. W. of Washington, D. C. Md.	Gneisses, decomposed to clay	Upland peat	Subacid	Common
Mountain ridges eastern counties, W.Va.	Siliceous rocks	Upland peat	Subacid	Common

Coastal Plain. (Carolinian Zone).

Swamps and uplands pine-barrens.......N. J.	Siliceous sands	Bog and upland peats	Mediacid	Abundant
Swamps and uplands marginal areas.....N. J.	Subcalcareous sands, clays	Upland peats	Subacid	Common
Swamps and uplands southern counties ..Del.	Siliceous sands	Bog and upland peats	Mediacid	Abundant
Swamps and uplands east of Wash., D. C. Md.	Siliceous sands	Bog and upland peats	Mediacid	Abundant

Grateful acknowledgement is made herewith to those who have acted as guides in several of these places; to Dr. Everett G. Logue and Mr. John P. Young, in central Pennsylvania; Messrs. Harold W. Pretz and Edward S. Mattern, in eastern Pennsylvania; Professor H. Justin Roddy, in southern Pennsylvania; and to Mr. Harry W. Trudell, who has taken part in many of the expeditions, and whose aid in pressing specimens of plants and in many other respects has greatly facilitated the covering of the ground and the obtaining of the data.

Descriptions of Individual Localities

A. Appalachian Mountain and Piedmont. (Alleghanian Zone.)

Swamps north of Dover and south of Green Pond (Warren County) New Jersey.

These two localities in the New Jersey Highlands were selected from the large number available because they are easily accessible and appear to furnish the maximum possible contrast in soil acidity relations. Dover is on the main line of the Delaware, Lackawanna and Western Railroad about 65 kilometers (40 miles) northwest of New York City; Green Pond (one of several bodies of water in New Jersey bearing that name) is two miles east of Bridgeville station, on the "old line" of the same railroad, about 20 km. (12 miles) southeast of Delaware Water Gap. In the swamps 3 km. (2 miles) north of Dover, the country rock is granitic gneiss, and the glacial drift is dominantly siliceous in character, the swamp waters being as a result mediacid. In those south of Green Pond the country rock, at least of the valley in which the pond lies, is limestone, and the glacial drift contains abundant fragments of calcareous rocks; the pond is fed by springs arising through limestone, so that its water is subalkaline, and similar reactions are shown by the waters at various places in the swamps along the stream draining the pond. Marked differences in flora, in so far as its members are sensitive to soil reaction, would be expected to appear on comparing these two regions.

Ericaceae (used in the broad sense) are actually far more abundant in the Dover region, forming dense thickets; and two of them, *Kalmia latifolia* and *Vaccinium corymbosum,* become small trees. *Clethra alnifolia, Eubotrys racemosa,* and *Gaultheria procumbens* may be noted as species which grow here but appear to be absent at Green Pond. Noteworthy members of families other than *Ericaeae* present in some abundance are: *Smilax rotundifolia, Habenaria psycodes, Coptis trifolia, Spiraea tomentosa,* and *Ilicioides mucronata;* all these are absent or rare at Green Pond. To those who are susceptible to Rhus poisoning, the Dover swamps will be found far more pleasant than the Green Pond ones, for in the former *R. vernix* and *R. toxicodendron* are very rare.

While the water of the Green Pond swamps is more or less alkaline in reaction, soils of definite and even high acidity are also present there, in the form of hummocks and mounds of decaying vegetable matter mingled with sphagnum and other mosses. On ascending these the reaction becomes less alkaline, passes through neutrality, and often reaches mediacid character at the top. The Ericaceae growing in this swamp are exclusively limited to such mounds. The species noted comprise: *Azalea nudiflora* (rare); *A. viscosa; Kalmia angustifolia; Xolisma ligustrina; Gaylussacia baccata* (rare); *Vaccinium corymbosum;* and *Vaccinium macrocarpon.* The soils of these were found to range from mediacid to subacid, their roots apparently not extending into material so moistened by the swamp water as to have less acidity than this. Notable plants of other families showing the same relations are: *Cypripedium acaule, Coptis trifolia, Menyanthes trifoliata,* and *Linnaea borealis* var. *americana.*

On the other hand there are here a number of plants which grow entirely or chiefly in soils bathed by the alkaline water, and ranging from neutral to subalkaline in reaction. Such are *Cypripedium hirsutum* (*reginae*), *C. candidum, Betula pumila, Caltha palustris, Par-*

nassia caroliniana, *Rhamnus alnifolia*, and an appalling abundance of *Rhus vernix* and *R. toxicodendron*. All these but the last two seem quite absent from the Dover swamps.

The pitcher plant, *Sarracenia purpurea*, grows in both swamps, in the Green Pond one only in the moss hummocks; and the water in the "pitchers" shows some peculiar reactions. The writer has tested the water held by this plant in many localities, and has found it to be usually mediacid, or subacid, the acidity being no doubt due chiefly to dissolved carbon dioxide. In the Green Pond swamp, however, the water in the pitchers was found to be minimacid, neutral and even minimalkaline. It is possible that the plant may be able to absorb lime from the moss in which it is rooted, and excrete it into the pitcher liquid. It seems more probable, however, that lime is absorbed by the roots of the larch trees, (which are abundant in the Green Pond Swamps, though rare at Dover,) and of other shrubs and trees growing in the alkaline water; and that this lime, excreted upon the leaves of these trees, is washed off by the rain and thus gets into the upturned pitchers.

Mountain Ridges in the Central Counties of Pennsylvania.

Tests have been made of the soils of Ericaceae and other plants at a number of places in the mountains of Pennsylvania, from Scranton on the northeast to Williamsport on the northwest, and from Bethlehem on the southeast to Mont Alto on the southwest. A few of the most interesting localities will be described here in some detail, starting at the northeast end.

The most prominent ridges in the region are underlain by sandstone rocks, and the soils they yield are mostly mediacid to subacid. Lower elevations are occupied by shale rocks, which may also give rise to strongly acid soils. Under circumstances where accumulation of vegetable matter is prevented, the reactions connected with both these rock types may be minimacid to neutral. As an illustration, it may be noted that the fern *Cryptogramma stelleri* (*Pellaea gracilis*) usually described in manuals as a limestone species, was collected at Lincoln Falls, Sullivan County, miles away from any limestone. The rock is a red shale (of Devonian age) and the water oozing from it is neutral in reaction.

At South Stroudsburg the Rhododendron nursery of W. K. Labar was visited, and the methods of growing ericaceous plants there were kindly demonstrated by Mr. John van Kleef, the resident manager. The natural soil of this place is a calcareous glacial drift, averaging minimacid in reaction. A few Ericaceae, notably *Rhododendron maximum* and *Kalmia latifolia*, grow there naturally, and it has been found possible to introduce many other species. The acidity found seems rather low, judging from what has been observed in the course of these studies, for these plants to make the best growth, but peaty material of somewhat more acid reaction—subacid—is being brought from the Pocono region, and mixed with the native soil, the result being highly satisfactory. At most other places within the glaciated area the drift is dominantly siliceous, and the soil reactions more strongly acid, Ericaceae being widespread and abundant at many points.

It was particularly desired to obtain data as to the behavior of ericaceous plants at or near a contact of a siliceous rock with a limestone; and one such locality was found, near the country club, some 3 km. (2 miles) east of Williamsport, Lycoming County. Near the main road (from Williamsport to Montoursville) there is an old limestone quarry; on the waste ground around it is a dense thicket of various shrubs bearing small, juicy fruits; the call of catbirds from the thicket suggesting how these shrubs may have been introduced. There were one or more species of *Celtis*, *Prunus*, *Crataegus*, *Rhus*, *Celastrus*, *Sambucus*, etc., present; but in spite of thorough search, not a single member of the Ericaceae could be found, although colonies of these plants, from which the birds no doubt obtain much food, are present within a few hundred meters. Evidently the seeds of the Ericaceae, when they fall into the limestone soil, either do not germinate at all, of if they do, the young plants soon succumb. Tests of the soil showed its reaction to vary from neutral to minimalkaline.

Going north from this quarry, around the end of a golf course, the limestone rock gives way to shale and this in turn to sandstone, a thin oak woods spreading over the contacts of these formations. As the limestone is receded from, the soils become more and more acid, and Ericaceae gradually appear. The first species was found to be *Vaccinium vacillans;* its soil proved to be minimacid. *Gaylussacia baccata* and *Azalea nudiflora* come in a short distance further on; their soils being minimacid to subacid. On reaching the sandstone formation Ericaceae appear in abundance, the above mentioned species being still present, and in addition *Kalmia latifolia*, *Gaultheria procumbens*, *Epigaea repens* and *Vaccinium corymbosum*. Various species of pine trees, and other acid soil plants, such as *Lupinus perennis*, come in here also; and tests of the soishowed subacid to mediacid reaction. The control of the distribul tion of Ericaceae by the soil reaction is here so evident as to require no further comment.

No other localities in the mountain region need special description, the acidities of the soils of Ericaceae observed there being included below, but the data which have been obtained on a few plants of other families than Ericaceae may be added here. The following were found to be limited to mediacid or occasionally subacid soils: *Clintonia borealis, Trillium erythrocarpum, Tiarella cordifolia, Dalibarda repens, Waldsteinia fragarioides, Oxalis acetosella, Polygala paucifolia,* and *Trientalis borealis.* In circumneutral soils, rarely ranging to subacid, characteristic plants are: *Cryptogramma stelleri* (*Pellaea gracilis*), *Filix fragilis, F. bulbifera, Camptosorus rhizophyllus, Allium tricoccum, Aquilegia canadensis,* and *Castilleja coccinea.* Wide range of reaction is shown by *Taxus canadensis, Trillium erectum, Clematis verticillaris, Hepatica acutiloba, Viola pedata,* etc. Finally it may be noted that *Phlox subulata,* while its acidity range is wide, shows more or less correlation of flower-color with soil reaction, in that the deep rose-violet flowered plants are usually found to grow in soil of lower acidity than those with pale rose or white flowers. There are, of course, cases in which both grow in close association, and where this relation does not hold, but in general it seems to be fairly definite.

Valleys in East Central Counties of Pennsylvania

The Lehigh-Lebanon valley of eastern Pennsylvania is largely underlain by limestone rocks, but at many places there is a thin layer of glacial drift over the limestone. The soil reactions associated with such a geological relationship and the resulting distribution of Ericaceae are matters of considerable interest. Tests have shown that the soil of unprotected limestone rock is normally minimalkaline or neutral in reaction; but that where the glacial drift occurs, upland peat tends to develop, often reaching a minimacid and occasionally even as high as subacid reaction. Woods in which many acid soil plants grow can develop in such drift-covered places, but where these woods are cut over and the acid upland peat material is given a chance to decompose, the acidity may decrease decidedly. No doubt under such circumstances those species which require the most acid conditions die out rapidly, while those which can adapt themselves to a less degree of acidity persist for some time, even to the point where the reaction goes down to the neutral point.

In the "Big Woods," about 6.5 km. (4 miles) southwest of Allentown, Lehigh County, Pa., the drift covering is thick enough to permit the growth of pine trees, and tests have shown the soil acidity of the upland peat to range from subacid down to minimacid. Here were noted the Ericaceae: *Pyrola americana*, *Chimaphila maculata*, *C. umbellata*, *Gaylussacia baccata*, and *Vaccinium stamineum*. In addition *Cypripedium acaule* and *Viola pedata*, regarded as acid soil plants, thrive here.

Some 5 km. (3 miles) northwest of this point is a small knoll formerly occupied by similar woods, but cut over several years ago. The humus has been extensively destroyed, and the soil acids neutralized by the underlying limestone, so that the acidity at present is minimacid, but the following Ericaceae have persisted: *Azalea nudiflora*, *Gaylussacia baccata*, *Vaccinium stamineum*, *V. vacillans*, and *V. corymbosum*. With these are *Comptonia asplenifolia* (*peregrina*) and *Viola pedata*, the soil of the last in some cases reaching actual neutrality, a rather unusual occurrence. (This observation was made in early spring; later in the season slight acidity may develop there).

Similar relations have been observed at some five localities, and are no doubt present at other places through this limestone valley, but nowhere have Ericaceae or other plants usually limited to highly acid soils been found to grow in the neutral to subalkaline soils of the limestone itself.

Hills in Southeastern Counties of Pennsylvania.

Describing in this province, as in previous ones, only particularly interesting occurrences, mention may first be made of a contact of sandstone and limestone at Fruitville, Lancaster County. On the sandstone, where the soils range in acidity from mediacid down, Ericaceae such as *Azalea nudiflora*, *Gaylussacia baccata*, *Vaccinium stamineum*, and *V. vacillans* are abundant. On passing over the contact toward the limestone side, these gradually die out, but two of them, the *Gaylussacia* and *Vaccinium vacillans*, extend into limestone soil of neutral reaction. It should be noted, however, that these plants are there stunted and obviously not thriving; and they are absent entirely when the soil becomes actually alkaline.

Thus far acidity data have been given chiefly for sandstone and limestone, so it may be of interest to add what has been observed, in the present region, about other formations. Mica schist and mica gneiss seem to yield normally subacid reactions. Trap rock (diabase) in spite of a rather high content of alkali and alkaline earth metals,—sodium, calcium, magnesium,—gives mostly subacid to minimacid soils. Serpentine behaves similarly, and subacid or even mediacid soils often develop, in spite of the magnesium content. The red shale formation of Triassic age, which covers a wide area in this part of Pennsylvania, yields subacid soils in many places, but since some of its strata contain considerable calcium carbonate, minimacid, neutral, and even minimalkaline soils are at times present upon it. The abundance of Ericaceae on these several formations has been found to follow closely the development of soils of subacid or mediacid reaction.

Hills Northwest of Washington, D. C.

On coming further south, the rocks are mostly more fully decomposed than they are in Pennsylvania, and the alkali metals are more extensively leached out, so that hills are often covered with dense clays, showing but little similarity to the original rocks. Subacid soils have been found to be dominant in such situations, and *Ericaceae* accordingly fairly common. Along the Potomac Valley northwest of Washington, D. C., the clays are considerably eroded, and the solid rock exposed; but here a secondary factor influences the soil reaction. The Potomac River and its tributaries flow for long distances through limestone regions, and take up considerable amounts of calcium bicarbonate. Not only does this make the waters themselves minimalkaline, but the sands and muds deposited at flood times also contain so much calcareous matter as to render the soils there circumneutral in reaction. Accordingly the Ericaceae, which grow on the uplands, drop off markedly as the level of river deposition is approached, and circumneutral-soil plants are common at the lower levels.

Mountain Ridges of West Virginia.

In the mountains of West Virginia, conditions are similar to those in the corresponding regions of Pennsylvania. The Ericaceae characteristic of the southern Appalachian Mountains reach their northern limits there, but they have not been found to show on the whole any differences in soil acidity from the Ericaceae which also grow farther north. The upland peat of the great *Rhododendron* thickets is mediacid to subacid in reaction, the plant roots usually extending down into material of the lesser acidity. The reactions of the soils of individual species are listed below.

B. Coastal Plain. (Carolinian Zone.)

Pine Barrens and Marginal Areas of New Jersey.

The correlation between soils and plants in southern New Jersey will be discussed by the writer elsewhere. The following is a summary of the conclusions there reached.

As every botanist interested in plant distribution has undoubtedly become acquainted with Stone's "Plants of Southern New Jersey," no description of the plants of this region need be given here. As to soils, although pure quartz sand should react neutral toward indicators, that of the Pine-barren area seems to be always more or less acid, no doubt owing to the accumulation of invisible humus matter between the grains; and where the humus is prominent, the reaction is usually mediacid, so that the Pine-barren area can be regarded as essentially a vast expanse of highly acid soils. On digging down through the surface layers of these soils, the acidity gradually decreases, and at a depth of three or four decimeters may be minimacid. Road-cuts and stream valleys through the region readily reach the levels of lower acidity, and on their banks grow plants which do best under somewhat less acid conditions, *Asplenium platyneuron* being a typical example.

The upper part of the Middle District or Marl area differs from the Pine-barren area in that mediacid soils are comparatively rare, the sands containing greater amounts of compounds of calcium and other elements which tend to neutralize more or less such acids as develop. The strata of Cretaceous age which outcrop are well known to contain considerable calcium carbonate derived from fossil shells, and the soil has in fact been found to reach neutral or even minimalkaline reaction in certain places, as for instance, the Lindenwold bog. In the Cohansey and Cape May areas the acidity also averages low, the source of the lime appearing to be sediments deposited in Quaternary times by the Delaware River, which drains vast areas of limestone rocks in its upper reaches, and the water of which is today slightly alkaline. In the Coastal area the sandy soils are mediacid as in the Pine-barrens, but contain considerable sodium chloride, calcium sulfate, etc., so that plants which require high content of salts, but are indifferent to acidity as such, together with those which require acidity but are tolerant of salts, are characteristic of this area.

The distribution of plants is evidently controlled to a marked degree by these features of the soils. As Stone remarks "The Pines seem to be the chosen land of the Ericaceae, which abound there both in species and individuals."[5] Many ericaceous species which are shown by studies in other regions to prefer mediacid or high subacid soils thrive in the Pine-barrens, whereas those requiring less acid conditions, such as the Pyrolas and Chimaphilas, are there infrequent, rare or unknown. On the other hand, plants which in the north are regarded as "calciphiles"—circumneutral soil plants—extend into southern New Jersey only along the marginal regions. To give but one example, *Gentiana crinita* is, as noted by Stone, a rarity in southern New Jersey; but in the Lindenwold bog it grows in wonderful abundance, being limited to the lower levels, where the calcareous strata outcrop, and neutralize the soil.

Southern Delaware.

During March, 1919, the writer visited the region around Millsboro, Sussex County, Delaware, to study the soil acidity as related to the distribution of native plants. The selection of this particular place was due to the reported occurrence there of the box-leaved huckleberry, *Gaylussacia brachycera* (Michx.), of which living specimens were desired. The earliness of the trip was determined by the fact that this plant is an evergreen and seemed likely to be most readily found before the leaves had developed on the majority of other plants. After several days' search a single small colony of the *Gaylussacia* was located, many acidity tests of the soils met with being carried out in the course of the trip. The results of these studies are here presented; since this region is less well known than those previously described, it is treated in greater detail.

The Millsboro region lies on that part of the Atlantic Coastal Plain known as the Delaware Peninsula or "Eastern Shore" (of Chesapeake Bay) District, about 16 km. (10 miles) back from the sea coast, and a like distance from the southern boundary of the state of Delaware. It is best reached by train on the Franklin City branch of the Delaware, Maryland and Virginia Railroad, a part of the Pennsylvania system, running south from Wilmington, Delaware. It is a region of low relief, the Indian River, which traverses it, being a tidal estuary, while the maximum elevation is little over 12 meters (40 feet) above sea level. The geological formation exposed at the surface of the ground is the Talbot formation, of Pleistocene age, consisting of unconsolidated sand, with occasional lenses of gravel and of clay, and the soils correspond in character.

[5]The Plants of Southern New Jersey. . . . Trenton, 1911, p. 617.

The growing season, or interval between average dates of minimum temperatures of 0° C (32° F.), is about 200 days in length.

The region around Millsboro is farmed extensively, but the native vegetation is preserved here and there, especially along the banks of streams. The dominant tree is *Pinus taeda*, and mingled with it are *P. serotina*, *P. echinata*, *P. rigida*, and *P. virginiana*. Oaks, maples, and gums are the principal deciduous trees. In the swamps occur *Chamaecyparis thuyoides* and rarely *Taxodium distichum*. A striking feature of the pine forests is the sparsity of the undergrowth, in which they resemble the southern rather than the New Jersey Pine-barren regions.[6]

The most prominent smaller trees and shrubs include *Myrica caroliniensis*, *Magnolia virginiana*, *Alnus rugosa* and the southern species *A. maritima*, *Ilex opaca*, *I. glabra*, *Pyrus* (*Aronia*) *arbutifolia*, *Aralia spinosa*, *Cornus florida*, and some 15 ericaceous plants, divisible into two groups: those of mediacid, and those of subacid soil. The mediacid soil species which mostly grow in swamps, are: *Clethra alnifolia*, *Azalea viscosa*, *Kalmia angustifolia*, *Eubotrys racemosa*, *Xolisma ligustrina*, *Gaultheria procumbens* and *Vaccinium corymbosum*. The *Gaylussacia brachycera* itself grows in dry upland peat with mediacid to high subacid reaction. The species more characteristic of dry subacid soils are: *Chimaphila maculata*, *C. umbellata*, *Azalea nudiflora*, *Kalmia latifolia*, *Epigaea repens*, *Gaylussacia baccata*, and *Vaccinium vacillans*.

Mediacid reaction was found to be present practically throughout the swamps, both in the water and the peat, and also in upland peat of the dry hills. On digging down into the sand beneath such upland peat, the acidity was found to decrease markedly, the measurements being: Surface, specific acidity 300; 25 centimeters down, 100; 50 cm. down, 30; and 100 cm. down, 10. As in the New Jersey Pine-barrens, both natural and artificial depressions often show the lower acidities on their banks, which relation controls to a certain extent the distribution of plants.

Two plants were observed to grow in this region which are elsewhere characteristic of circumneutral soils, *Asplenium platyneuron* and *Aquilegia canadensis*. The first appears chiefly in isolated patches in the pine woods, where either because of the presence of bacteria able to decompose the acid constituents of the upland peat,

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[6]Compare Harper, *Bull. Torrey Bot. Club*, **37**: 426, 1910; *Bull. Geogr. Soc. Phila.* **16**: 14, 1918.

or of lenses of calcareous clay, the acidity of the soils is markedly diminished. These areas, mostly only a few meters in diameter, and more or less circular in outline, are scattered through the woods, forming in a sense oases in the desert; with the exception of *Chimaphila maculata*, the Ericaceae appear to avoid them. Wherever *Asplenium* showed up in the forest floor,—and it was very prominent, the fronds attaining lengths of as much as 40 cm.,—tests invariably showed the area it occupied to be subacid or circumneutral in reaction. Presumably the spores of this fern are killed when they fall into the more acid soils of the region.

The *Aquilegia*, together with a few plants of *Asplenium*, was observed in quite a different habitat, namely, on the steep banks of the Indian River. The low acidities observed were in this case obviously connected with the fact that the plant roots entered directly the lower layers of the soil, which are everywhere less acid than the surface portions. *Epigaea repens* was also found to grow on the same banks, but its roots do not enter the low acid sands to any extent, being instead imbedded in superficial peaty material with the usual mediacid reaction.

Another type of relationship is shown by *Yucca filamentosa*, the optimum for which appears to lie at specific acidity 30. This plant grows, apparently as a native and not an escape, in large patches in the more open pine woods, where the surface soil is upland peat with mediacid reaction. It has, however, an erect underground stem 25 or more cm. long, at the base of which is a cluster of tuberous roots, with fibrous ones extending downward from them. As far as its root system is concerned, therefore, this species is growing not in highly acid, but in subacid soils.

Region East of Washington, D. C.

The region east of Washington is so similar to the New Jersey and Delaware areas already discussed that little need be said about it at this point. Plant distribution is elaborately treated in a recent publication.[7] The magnolia bogs as therein defined are dominantly mediacid in reaction, and the upland peat of the dry surrounding hillsides attains the same acidity, so that Ericaceae and their usual associates abound in both habitats. Subacid and rarely minimacid soils occur on banks and locally through the woods, and support a few plants which can not stand the higher acidities.

[7] McAtee, W. L. A sketch of the Natural History of the District of Columbia, *Bull. Biol. Soc. Wash.*, **1**: 142 pp., 1918.

Many tests made in this region are included in the tables for individual ericaceous species which follow.

Observations on Individual Species

In order to bring out the acidity relations of the individual species, the plan suggested in the paper above cited[8] has been modified in such a manner that while the specific acidities are plotted horizontally the number of places where each value has been observed are now plotted vertically. Thus, on p. 97, when a given species has been found to grow in a soil with specific acidity = 100 at two different localities (or distinctly different habitats in the same locality) an *x* is placed above the figure 100 and opposite the number 2. Observations in nurseries are marked with *n*, and those made in other regions, which seem worth introducing for comparison, with *o*. A curve may be regarded as drawn through the points thus marked, and from its shape the behavior of the plant with respect to soil acidity may be seen at a glance. In most Ericaceae the curves indicate that there is a definite limit to growth on the less acid side. and sometimes on the more acid side as well. There is also in most cases a maximum in the curve,—an intermediate point—at which the species is observed to grow with such frequence and luxuriance that this value is to be regarded as its optimum reaction under natural conditions.

Each species has been examined, on the average, at 10 localities selected so as to show as wide a range of conditions as possible. Tests have been made at each locality in sufficient number to insure the records being typical of the occurrence. Identifications of the plants have been made with care, specimens of each being preserved, and in cases of uncertainty submitted to authorities on the groups concerned. While freely admitting that there is room for additional data from other regions the writer feels that in most cases observations enough have been made to justify accepting with some degree of confidence the definiteness of the optimum and limiting reactions indicated.

The American code of Nomenclature is followed for the most part; but the genus-splitting favored in Britton and Brown's "Illustrated Flora" and the "North American Flora" is not accepted.

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[8]*Rhodora*, **21**: 43 1920.

Clethra alnifolia L.

Habitat.—Wet sphagnum peat and occasionally dry upland peat at swamp margins.

Acidity.—

5+	x					
4						
3						
2		x				
1			x	n		
	300	100	30	10	3	1
	Mediacid		Subacid		Miniacid	Neutral[9]

The optimum soil reaction for this species is obviously mediacid. The lower values sometimes observed represent places where the plant pushes out from its usual swamp habitat into dry sandy woods. The *n* in the table refers to a test of sandy soil in Gillett's nursery at Southwick, Massachusetts, and is introduced to show that this plant can be grown under cultivation in a soil of somewhat lower initial acidity than it appears to occupy in nature.

Pyrola americana Sweet.

Habitat.—Dry upland peat and occasionally moist peat at swamp margins.

Acidity.—

5+			x			
4						
3				x		
2						
1	x	x			x	
	300	100	30	10	3	1

The optimum soil reaction for this species is subacid. The most acid reaction tabulated was observed in moist peat at the margin of a swamp north of Dover, N. J. The least acid was noted in upland peat on glacial drift overlying limestone in the Lehigh Valley west of Allentown, Pa.

Pyrola elliptica Nuttall.

Habitat.—Dry and occasionally moist upland peat.

Acidity.—

5+				x		
4			x			
3				o		
2			o		o	
1		o				
	300	100	30	10	3	1

---

[9]In the succeeding tables these names are omitted for brevity. Their use in the text will be understood to imply the same degree of acidity here indicated.

The optimum soil reaction of this species is probably between subacid and minimacid; the tests made on it in New England, indicated by *o*'s, led to the same value.

Pyrola secunda L.

Habitat.—Dry and occasionally moist upland peat.

Acidity.—

5+			x			
4				x		
3			o			
2				o		
1		x			o	
	300	100	30	10	3	1

The optimum soil reaction of this species is inferred, from consideration of the data from both New England and the present region, to be subacid. The most acid reaction tabulated was observed in sandy upland peat in southern Delaware.

Chimaphila maculata (L.) Pursh.

Habitat.—Dry upland peat.

Acidity.—

5+			x			
4						
3						
2				x	x	
1	x	x				
	300	100	30	10	3	1

The optimum soil reaction of this species is subacid. The most acid reaction was observed in sandy upland peat in southern Delaware. The least acid was noted in upland peat on glacial drift overlying limestone in the Lehigh Valley west of Allentown, Pennsylvania, and in upland peat over limestone at Natural Bridge, Virginia.

Chimaphila umbellata (L.) Nuttall.

Habitat.—Dry upland peat.

Acidity.—

5+						
4			x			
3						
2			o	x		
1	x	x		o		
	300	100	30	10	3	1

The optimun soil reaction of this species is subacid. The most acid reaction was observed in sandy upland peat in southern Delaware.

Monotropa uniflora L.

Habitat.—Dry and occasionally moist upland peat.

Acidity.—

	300	100	30	10	3	1
5+			x			
4						
3						
2				x		
1		x				

The optimum soil reaction of this species is subacid; its range is apparently rather more limited than those of preceding members of the Ericaceae. The most acid reaction was noted in sandy upland peat in southern Delaware; the least acid in clayey upland peat at two widely separated localities near Washington, D. C.

Hypopitys lanuginosa (Michx.) Nuttall

Habitat.—Dry and occasionally moist upland peat.

Tests have been made on *Hypopitys* chiefly during the winter, and the species could not be accurately determined. Plants approaching *H. lanuginosa* in characters have been examined at two localities near Washington, D. C., in clayey upland peat, and yielded subacid reaction in both cases.

Hypopitys americana (De Candolle) Small.

Habitat.—Dry upland peat.

Plants probably referable to *H. americana* have been examined near Dover, N. J., the soil being sandy upland peat over glacial drift, and the reaction subacid.

Azalea nudiflora L.

Habitat.—Dry upland peat and occasionally wet sphagnum peat.

Acidity.—

	300	100	30	10	3	1
5+			x			
4				x		
3						
2						
1	x	x			x	

The optimum soil reaction of this species is subacid. The most acid reaction tabulated was observed in a swamp in southern Delaware; the least acid in upland peat over calcareous glacial drift near Green Pond, N. J.

Azalea canescens D. Don.

Habitat.—Dry upland peat.

This species has been observed but rarely, in the mountains of central Pennsylvania; the soil in these cases is upland peat over sandstone rocks, and the reaction subacid or rarely mediacid.

Azalea arborescens Pursh.

Habitat.—Moist upland peat.

This species has been observed in the mountains of eastern central West Virginia, chiefly in Tucker county. The soil is moist upland peat, and the usual reaction subacid.

Azalea viscosa L. (Including varieties glauca, nitida, etc.)

Habitat.—Wet sphagnum peat and occasionally dry upland peat at swamp margins.

Acidity.—

5+	x					
4						
3						
2						
1		x	x	n		
	300	100	30	10	3	1

The optimum soil reaction for this species is mediacid. The lower values noted represent places where the plant pushes out from its usual swamp habitat into dry sandy woods. The *n* in the table refers to Gillett's nursery at Southwick, Massachusetts. This makes with the preceding plant a pair of closely related species with marked dissimilarity in optimum soil reaction.

Rhododendron maximum L.

Habitat.—Moist and occasionally dry upland peat and wet sphagnum peat.

Acidity.—

5+			x			
4						
3	x					
2		x		x		
1					x	x
	300	100	30	10	3	1

The optimum soil reaction for this species appears to subacid, but its range is unusually wide. The most acid reaction tabulated represents occurrences in sphagnum peat in a swamp in central Lycoming County, Pa., and in moist upland peat in the mountains of West Virginia. The two least acid values were observed in upland peat on calcareous glacial drift east of Williamsport, Pa. While some of the roots of these plants were found to be surrounded by soils of these acidities, other roots of the same plants were in subacid soils. Seedlings have been found most frequently in subacid soils.

Menziesia pilosa (Michaux) Persoon.

Habitat.—Dry and occasionally moist upland peat.

This species has been observed only on Spruce Mountain and neighboring ridges in Pendleton County, West Virginia. The soils are upland peats over sandstone rocks, and the reaction is subacid to mediacid.

Dendrium buxifolium (Berg) Desvaux.

Habitat.—Moist and occasionally dry sand, and wet sphagnum peat.

This species has been observed at various places in central and southern New Jersey, being especially prominent in the Pine-barrens. Its soils show in practically every case a mediacid reaction, rarely approaching subacidity. In its typical occurrences in white sand, this acidity appears to be due to the presence of autogenous humus, that is, humus formed by the decomposition of the leaves of the plant itself.

Kalmia latifolia L.

Habitat.—Dry upland peat and wet sphagnum peat.

Acidity.

5+			x			
4	x					
3		x				
2						
1				x		
	300	100	30	10	3	1

The optimum soil reaction of this species is probably subacid, but it is of frequent occurrence in mediacid soils too. The lowest acidity tabulated was noted in upland peat over calcareous glacial drift near Stroudsburg, Pa. Seedlings have been observed most frequently in subacid soils.

Ka'mia angustifolia L.

Habitat.—Wet sphagnum peat, moist and dry upland peat, and dry sand.

Acidity.—

5+	x					
4						
3		x	x			
2	o	o				
1			o	n		
	300	100	30	10	3	1

The optimum soil reaction of this species is probably mediacid, but it is also frequently found in subacid soils. In northern New England it is most often met with in mediacid peat, and seedlings have been observed only in such material. Subacid reactions have been noted in upland peats in the Pennsylvania mountains, and in gravel in the Saucon Valley, eastern Pennsylvania, as well as in Vermont. And as indicated by the *n* in the table, it can be grown under cultivation in soils of as low an acidity as minimacid.

Eubotrys racemosa (L.) Nuttall.

Habitat.—Wet sphagnum peat, wet and dry upland peat.

Acidity.—

5+						
4	x	x	x			
3						
2						
1				x		
	300	100	30	10	3	1

The optimum soil reaction of this species is probably subacid, although it is also rather frequent in mediacid soils. The least acid reaction listed was observed in an occurrence in dry upland peat on schistose rocks northwest of Washington, D. C.

Neopieris mariana (L.) Britton.

Habitat.—Dry upland peat and occasionally moist peat.

Acidity.—

5+						
4	x					
3						
2						
1		x	x			
	300	100	30	10	3	1

The optimum soil reaction of this species is probably mediacid. The least acid reaction tabulated was observed in dry sand south of the New Jersey Pine-barrens.

Xolisma ligustrina (L.) Britton.

Habitat.—Dry upland peat and wet sphagnum peat.

Acidity.—

5+						
4	x		x			
3		x				
2						
1				x		
	300	100	30	10	3	1

The optimum soil reaction of this species is probably subacid, although it is also of frequent occurrence in mediacid soils. The least acid value tabulated was noted in dry upland peat on calcareous glacial drift near Green Pond, New Jersey.

Chamaedaphne calyculata (L.) Moench.

Habitat.—Wet sphagnum peat and occasionally dry upland peat.

Acidity.—

5+	x					
4						
3		x				
2		o				
1	o		o	o		
	300	100	30	10	3	1

The optimum soil reaction of this species is probably mediacid. The lowest acidities tabulated, marked *o*, represent an occurrence south of Willoughby Lake, Vt., where the plant grows at the margin of an alkaline water pond, and its roots push out as far as material of this acidity. It is also grown in nurseries in dry sandy soil between subacid and minimacid in reaction.

Oxydendrum arboreum (L.) DeCandolle.

Habitat.—Dry upland peat.

As observed in southern Virginia, this plant grows in woods where the surface soil is mediacid, but its roots usually extend down into material of subacid reaction.

Epigaea repens L.

Habitat.—Dry upland peat and occasionally moist peat.

Acidity.—

5+			x			
4	x					
3		x				
2				x		
1						
	300	100	30	10	3	1

The optimum soil reaction of this species is probably subacid, although it is fairly common in mediacid soils as well. The least acid reactions tabulated were observed in upland peats near Washington, D. C. The most heavily fruiting plants and the most numerous seedlings have been found in subacid soils.

Gaultheria procumbens L.

Habitat.—Dry and moist upland peat, and wet sphagnum peat.

Acidity.—

5+	x					
4						
3						
2		x	x			
1				o		
	300	100	30	10	3	1

The optimum soil reaction of this species is probably mediacid, although it is fairly common in subacid soils as well. The least acid reaction (o) was observed in upland peat on calcareous glacial drift near Fairlee, Vt.

Arctostaphylos uva-ursi L.

Habitat.—Dry upland peat.

This species has been observed at two widely separated localities in the Pine-barrens of New Jersey, in upland peat and in white sand rendered acid by autogenous humus, the reaction being mediacid. A soil sample from a colony growing on trap rock in south central Connecticut, kindly submitted by Mr. C. A. Weatherby, proved to be subacid. On the other hand, it is reported by Fernald[10] from cliffs of limestone at Bic, Quebec; and Mr. Coville informs the writer that he has collected it on limestone north of Lake Superior. In both these occurrences the soils are presumably at most minimacid, if not neutral or alkaline, which would indicate that the species has a wide range of soil reaction.

In the Alps something of the same sort has been noted. According to Schroeter:[11]

"In Wallis it is according to Jaccard calciphilous, likewise in the Bavarian Alps according to Sendner, while Contejean designates it as calciphobous, and Mangin and Lecoq as indifferent. According to my experience it is calciphilous in the Swiss Alps." Yet Warming[13] includes it among oxylophytes or acid soil plants. Further study of this plant is desirable to ascertain whether there are any varietal differences associated with these divergences of soil reaction.

Chiogenes hispidula (L.) T. & G.

Habitat.—Moist and occasionally dry upland peat and wet sphagnum peat.

Acidity.—

5+	x					
4						
3						
2	o	x				
1			x			
	300	100	30	10	3	1

The optimum soil reaction of this species is mediacid, which has been obtained at stations in the mountains of Pennsylvania and West Virginia, as well as in northern New England. It is interesting to note that Thoreau[14] pointed out that the Indian name for this plant means "grows where trees have rotted," rotting wood being usually strongly acid in reaction.

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[10] *Rhodora*, **9**: 163, 1907.
[11] Das Pflanzenleben der Alpen, Zürich, 1908; p. 156.
[13] Oecology of plants, Oxford, 1909; page 211.
[14] "The Maine Woods."

Gaylussacia brachycera (Michx.) Gray.

Habitat.—Dry upland peat.

This species has been studied at the two stations known at present, New Bloomfield, Pa., and Millsboro, Del.[15] In both places the dominant soil acidity around its roots is mediacid, ranging to subacid here and there. At the Pennsylvania locality the underlying clayey soil (derived from disintegration of Devonian shale) is lower than this in acidity, being minimacid, but the plant tends to avoid the raw soil, and to grow most profusely wherever vegetable matter is in course of decay. It follows especially the courses of old fallen tree trunks, (and stumps), which are thereby outlined in green against the dominant brown of the surrounding soil. In the Delaware colony the underlying soil is white sand rendered mediacid by admixture of humus and covered by a thick carpet of upland peat made up of *Kalmia* leaves and pine needles; and the plant grows in a single compact mat, some 20 feet in diameter, being apparently prevented by climatic conditions or by some parasite from spreading into similar soil surrounding the area.

Gaylussacia dumosa (Andrews) T. & G.

Habitat.—Wet sphagnum peat.

This species has been observed in but two regions, the New Jersey Pine-barrens and the Coastal Plain swamps east of Washington, D. C. The dominant soil reaction in both places is mediacid.

Gaylussacia frondosa (L.) T. & G.

Habitat.—Wet sphagnum peat, moist and dry upland peat.

Acidity.—

5+						
4	x					
3						
2						
1		x	x			
	300	100	30	10	3	1

The optimum soil reaction of this species is mediacid. The lowest acidity tabulated was observed in dry woods south of the New Jersey Pine-barrens.

Gaylussacia baccata (Wang.) Koch.

Habitat.—Dry and moist upland peat and occasionally wet sphagnum peat.

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[15] *Science*, **50**: 30–34, 1919.

Acidity.—

5+			x			
4				x		
3						
2	x	x				
1					x	x
	300	100	30	10	3	1

The optimum soil reaction of this species is subacid. The most acid reactions tabulated were observed in swamps north of Dover, N. J., and in southern Delaware. The least acid was noted in Lancaster County, Pa., at the contact of sandstone and limestone formations, this *Gaylussacia*, along with one *Vaccinium*, extending a short distance over on to the limestone side.

Vaccinium stamineum L.

Habitat.—Dry and occasionally moist upland peat.

Acidity.—

5+			x			
4				x		
3						
2						
1		x			x	
	300	100	30	10	3	1

The optimum soil reaction for this species is subacid. The least acid reaction tabulated was observed in upland peat on decomposed diorite-gneiss rock southwest of Allentown, Pa.

Vaccinium pennsylvanicum Lamarck.

Habitat.—Dry and occasionally moist upland peat.

Acidity.—

5+			x			
4						
3	x					
2		x		x		
1	o	o				
	300	100	30	10	3	1

The optimum soil reaction for this species is apparently subacid. In the White Mountains (indicated by the *o* in the table) its soils are mediacid, but the plant there is distinct in several respects from the one found in the Middle Atlantic States. In Gray's Manual this northern form is distinguished (as var. *angustifolium* (Ait.) Gray). The lowest acidities tabulated were observed near Wilkesbarre, Pa., and on a sample of soil kindly submitted by Professor George S. Perry of the Pennsylvania Forest Academy from near Mont Alto.

Vaccinium vacillans Kalm.

Habitat.—Dry and occasionally moist upland peat.

Acidity.—

5+			x			
4				x		
3						
2	x	x			x	x
1						
	300	100	30	10	3	1

The optimum soil reaction of this species is subacid. The least acid reaction tabulated, actual neutrality, was observed in Lancaster County, Pa., at the contact of sandstone and limestone formations, this species extending over onto the limestone. At other contacts it is one of the earliest of the Ericaceae to appear as the limestone is receded from.

Vaccinium corymbosum L.

Habitat.—Wet sphagnum peat and moist and occasionally dry upland peat.

Acidity.—

5+	x		x			
4						
3		x				
2				x		
1					x	
	300	100	30	10	3	1

The optimum soil reaction of this species is probably subacid, although it is common in mediacid soils as well. The lowest acidities tabulated were observed in the Lehigh Valley west of Allentown, Pa., in upland peat on glacial drift overlying limestone.

Vaccinium atrococcum (A. Gray) Heller.

Habitat.—Wet sphagnum peat and moist and occasionally dry upland peat.

Acidity.—

5+						
4						
3			x	x		
2						
1	x	x			x	
	300	100	30	10	3	1

The optimum soil reaction of this species is probably subacid. The lowest acidity tabulated was observed in upland peat on glacial drift overlying limestone in the Lehigh Valley west of Allentown, Pa.

Vaccinium erythrocarpum Michaux.

Habitat.—Moist and dry upland peat.

This species has been observed only in the mountains in Pendleton County, West Virginia. The soil acidity was found to be mediacid in most cases, occasionally ranging to subacid.

Vaccinium oxycoccos L.

Habitat.—Wet sphagnum peat.

In addition to occurrences in New England, this species has been observed only in a swamp in eastern Lycoming County, Pa.; in all cases the soil is mediacid.

Vaccinium macrocarpon Aiton.

Habitat.—Wet sphagnum peat.

This species has been observed in swamps in many places in New Jersey and Pennsylvania, the soil acidity being mediacid, or rarely subacid.

Pyxidanthera barbulata Michaux.

Habitat.—Dry and occasionally moist upland peat.

This species has been observed at many places in the New Jersey Pine Barrens, in mediacid and rarely subacid upland peat and white sand, the acidity of the latter being due to the development of autogenous humus beneath the mats of the plant.

Galax aphylla L.

Habitat.—Dry upland peat.

This plant has been observed in the mountains of southwestern Virginia, growing in open woods, with *Epigaea* and various *Vaccinium,* in mediacid or less commonly subacid soils.

Corema conradii Torrey.

Habitat.—Dry upland peat.

Included here in view of the opinion of some botanists that this family probably represents a degenerate member of the Ericales. This species has been observed only in the Plains, east of Chatsworth, in the heart of the New Jersey Pine-barrens. It grows in white sand, mingled with autogenous humus, the reaction being mediacid.

By tabulating the data, the relative acidity requirements of the various species may be made clearly evident. Bold face **X**'s mark optimum values, ordinary-face capitals frequently observed values, small *x*'s occasional ones, *o*'s observations in other regions, and *n*'s tests in nurseries.

TABLE 2.

Acidity Relations of Ericaceae Studies

	Medi-acid		Sub-acid	Minim-acid		Neutral
	300	100	30	10	3	1
CLETHREAE.						
Clethra alnifolia	X	x	x	n	.	.
PYROLEAE						
Pyrola americana	x	x	X	X	x	.
elliptica	.	o	X	X	o	.
secunda	.	x	X	x	o	.
Chimaphila maculata	x	x	X	X	x	.
umbellata	x	x	X	X	.	.
MONOTROPOIDEAE						
Monotropa uniflora	.	x	X	x	.	.
Hypopitys lanuginosa	.	.	X	.	.	.
americana	.	.	X	.	.	.
ERICOIDEAE (ERICACEAE)						
Azalea nudiflora	x	x	X	X	x	.
canescens	x	x	X	.	.	.
arborescens	.	.	X	.	.	.
viscosa	X	x	x	n	.	.
Rhododendron maximum	X	X	X	x	x	x
Menziesia pilosa	x	x	X	.	.	.
Dendrium buxifolium	X	x	.	.	.	.
Kalmia latifolia	X	X	X	X	.	.
angustifolia	X	X	X	n	.	.
Eubotrys racemosa	X	X	X	x	.	.
Neopieris mariana	X	x	x	.	.	.
Xolisma ligustrina	X	X	X	x	.	.
Chamaedaphne calyculata	X	x	X	o	.	.
Oxydendrum arboreum	x	x	X	.	.	.
Epigaea repens	X	X	X	X	.	.
Gaultheria procumbens	X	X	X	o	.	.
Arctostaphylos uva-ursi	X	X	X	.	.	o
VACCINIOIDEAE (VACCINIACEAE)						
Chiogenes hispidula	X	x	x	.	.	.
Gaylussacia brachycera	X	x	x	.	.	.
dumosa	X	.	.	.	.	.
frondosa	X	x	x	.	.	.
baccata	x	X	X	X	x	x
Vaccinium stamineum	.	x	X	X	x	.
pennsylvanicum	X	X	X	x	.	.
vacillans	X	X	X	X	x	x
corymbosum	X	X	X	X	x	.
atrococcum	x	X	X	X	x	.
erythrocarpum	X	X	X	.	.	.
Oxycoccos	X	.	.	.	.	.
macrocarpon	X	x	x	.	.	.
DIAPENSIACEAE						
Pyxidanthera barbulata	X	x	x	.	.	.
Galax aphylla	X	x	x	.	.	.
EMPETRACEAE						
Corema conradii	X	x	.	.	.	.

In table 3 the Orchidaceae found in the Middle States are tabulated in a similar way. The article on this family previously published by the writer[16] included the same species, only two (marked by an asterisk) having been since observed, but the acidity data were given numerically, and no optimum reaction was indicated. In the present table, the reactions are shown graphically, the optimum point is indicated as with the Ericaceae, and several extensions of range found as the result of many tests made since the publication of the other paper are included.

Table 3

Reactions Relations of Orchidaceae Studied

	Specific acidity					Specific alkalinity		
	300	100	30	10	3	1	3	10
	Mediacid		Subacid	Minimacid		N	Minimalk.	
Cypripedium candidum	.	.	.	.	.	X	x	x
parviflorum	.	x	X	X	X	X	x	x
var. pubescens	.	x	X	X	X	X	x	x
hirsutum	.	.	.	o	o	X	x	x
acaule	X	X	X	x	.	.	.	.
Orchis (Galeorchis) spectabilis	.	.	x	X	X	X	x	x
Habenaria (Blephariglottis)								
blephariglottis	X	x	.	.	.	.	.	.
ciliaris	X	X	X	.	.	.	.	.
cristata	X	x	.	.	.	.	.	.
fimbriata (grandiflora)	.	x	X	x	.	.	.	.
lacera	x	X	X	X	.	.	.	.
peramoena	.	x	X	X	.	.	.	.
psycodes	X	X	X	X	x	o	.	.
(Coeloglossum) bracteata	.	x	X	x	.	.	.	.
(Gymnadeniopsis) clavellata	X	X	X	.	.	.	.	.
integra*	X	x	.	.	.	.	.	.
nivea	x	X	X	x	.	.	.	.
(Lysias) orbiculata	.	x	X	o	.	.	.	.
(Peruaria) flava	X	X	x	.	.	.	.	.
Limodorum tuberosum	X	x	x	.	.	.	.	.
Arethusa bulbosa	X	.	.	.	.	.	.	.
Pogonia ophioglossoides	X	x	x	.	.	.	.	.
divaricata*	X	x	.	.	.	.	.	.
(Triphora) trianthophora	.	.	x	x	X	x	.	.
(Isotria) verticillata	X	X	X	x	.	.	.	.
Ibidium beckii	X	X	X	.	.	.	.	.
cernuum	x	x	X	X	x	.	.	.
gracile	x	X	X	.	.	.	.	.
plantagineum (latifolium	.	x	X	X	X	.	.	.
odoratum	.	x	X	x	.	.	.	.
praecox	x	x	X	x	.	.	.	.
vernale	X	X	X	x	.	.	.	.

[16] *Journ. Wash. Acad. Sci.* 8, 590–598, 1918.

Peramium pubescens	.	x	X	X	.	.	.	.
repens	.	x	X	o	.	.	.	.
Serapias helleborine (viridiflora)	.	.	X	x	.	.	.	.
Malaxis unifolia	X	X	X	x	.	.	.	.
Liparis liliifolia	.	x	X	X	X	x	.	.
loeselii	x	x	X	X	x	o	.	.
Aplectrum hyemale (spicatum)	.	x	X	X	x	x	.	.
Tipuharia unifolia	x	x	X	X	.	.	.	.
Corallorrhiza maculata	.	x	X	x	.	.	.	.
odontorhiza	.	x	X	x	x	.	.	.
wisteriana	.	.	x	X	x	.	.	.